Metal to Insulator Transition in Films of Molecularly Linked Gold Nanoparticles

AMIR ZABET-KHOSOUSI, AL-AMIN DHIRANI, Department of Chemistry, University of Toronto — Self-assembled structures comprising nanoparticles (NPs) and molecular linkers exhibit remarkable electronic behaviours ranging from insulating to metallic. These behaviours can be controlled via chemical synthesis and choice of linker molecules. However, charge transport through these structures is not well understood. Here, we report a metal-insulator transition (MIT) in films of alkanedithiol ($C_nS_2$)-linked gold NPs, as the length of linkers ($n$) is systematically varied. Our results provide strong evidence for a MIT occurring at $n = 5$. We describe these results in a context of a Mott-Hubbard model. We find that all insulating samples ($n \geq 5$) exhibit a universal scaling behaviour $R \sim \exp[(T_0/T)^p]$ (where $R$ is resistance, $T$ is temperature, $T_0$ is a fitting parameter and $p = 0.65$), and all metallic samples ($n \leq 5$) exhibit weaker $R-T$ dependencies than bulk gold. We discuss these observations in terms of competitive thermally-activated processes and strong $T$-independent elastic scattering, respectively.